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SPECIFICATION

1. Title of the Invention
PIEZOELECTRIC SPEAKER

2. Claims

(1) A piezoelectric speaker characterized by comprising:

an elliptic piezoelectric ceramic plate;

a metal substrate bonded to the piezoelectric ceramic plate;

an edge member bonded to an outer circumference of the metal substrate;

a resin film bonded to an outer circumference of the edge member and having an outer circumference bonded to a frame;

a member for supporting the resin film; and

an additional mass formed of an elastic material and bonded to the piezoelectric ceramic plate at its center.

(2) A piezoelectric speaker according to claim 1, characterized in that the metal substrate is elliptic.

3. Detailed Description of the Invention

[Industrial Applicability]

The present invention relates to the improvement of a piezoelectric speaker using a piezoelectric ceramic plate.

[Prior Art]

A piezoelectric diaphragm used for a piezoelectric speaker has a structure in which circular piezoelectric ceramic plates are laid on opposite sides of a circular metal substrate, which is normally made of brass, aluminum, stainless steel, nickel, or the like, such that the circular piezoelectric ceramic plates and the circular metal substrate are bonded together. In general, the piezoelectric speaker is often used for a piezoelectric buzzer, etc. In recent years, vending machines have used piezoelectric speakers for reproducing a synthetic sound. However, as is well-known, the piezoelectric speaker has difficulty in performing low-frequency reproduction. Since repetition of resonance and antiresonance causes a highly turbulent frequency characteristic, the piezoelectric speaker cannot be recognized as having sufficient characteristics required for use in music reproduction. Thus, a variety of types of improvements have been suggested.

For example, in order to improve a low tone reproduction capability, attempts have been conducted for lowering a reference resonance frequency (f_0) by using a thinner piezoelectric ceramic plate and a thinner metal substrate and for suppressing generation of peaks and dips due to resonance and antiresonance by improving the quality and shape of the metal substrate and a support structure of the piezoelectric diaphragm. Further, as disclosed in Japanese Laid-Open Utility Model publication Nos. 55-21628 and 57-163898, piezoelectric speakers employing an elliptic piezoelectric ceramic plate so as to have an electrically double-humped characteristic have been suggested.

[Problems to be Solved by the Invention]

However, such a conventional piezoelectric speaker has not been improved to such an extent as to achieve a reproduction band required for enabling music reproduction and obtain a flat frequency characteristic.

For example, in order to improve the reproduction band, attempts to reduce the thickness of the piezoelectric diaphragm have been conducted. However, the rigidity of the piezoelectric ceramic plate is reduced and a distortion energy of the metal substrate is applied to the piezoelectric ceramic plate, thereby increasing harmonic distortion.

[Means for Solving the Problems]

The present invention provides a piezoelectric speaker using an elliptic piezoelectric ceramic plate in which the piezoelectric ceramic plates are bonded to a metal substrate, the outer circumference of the metal substrate is supported by an edge member, the edge member is connected to a frame via a resin film, and an additional mass formed of an elastic material is bonded to the piezoelectric ceramic plate at its center. Claim 2 of the present application is directed to a piezoelectric speaker including an elliptic metal substrate.

[Function]

An additional mass functions as an inertial mass at low frequencies so as to expand low frequency reproduction and a resonance absorption function of an elastic material suppresses the resonance at high frequencies.

[Examples]

Hereinafter, the present invention will be described with respect to an example illustrated in Figure 1.

In Figure 1, reference numeral 1 denotes piezoelectric ceramic plates each shaped like an ellipse having a long axis of 35.4 mm, a short axis of 17.7 mm, and a thickness of 0.05 mm. Reference numeral 2 denotes a nickel alloy plate to which the piezoelectric ceramic plates are bonded to opposite sides thereof via an adhesive. The nickel alloy plate is shaped like an ellipse having a long axis of 52.0 mm, a short axis of 30.0 mm, and a thickness of 0.05 mm. Reference numeral 3 denotes an edge member bonded to the outer circumference of the nickel alloy plate via an adhesive. The edge member is made of a thermoplastic resin film having a thickness of 1 mm and a width of 5.0 mm. Reference numeral 4 denotes the resin film bonded to the outer circumference of the edge member via an adhesive. The resin film has a circular appearance and is 60.0 mm in diameter. Reference numeral 5 denotes a ring-like frame bonded to the circumference of the resin film 4 via an adhesive. Reference numeral 6 denotes an additional weight member made of a polypropylene resin bonded to one of the piezoelectric ceramic plates 1 at its center via an adhesive (preferably an adhesive maintaining viscoelasticity). The additional weight member is shaped like an ellipse having a long axis of 28.0 mm, a short axis of 14.0 mm, and a thickness of 0.2 mm. Further, the additional weight member includes input means for inputting a signal to the piezoelectric ceramic plate which is not shown. A frequency characteristic of the piezoelectric speaker is shown in Figure 2.

Note that in Figure 2, Comparative Example 1 refers to a frequency characteristic of a piezoelectric speaker identical to that shown in Figure 1 in terms of

configuration, except that the additional mass is not included and each of the piezoelectric ceramic plate and the metal substrate has a circular shape. Specifically, the piezoelectric speaker referred to by Comparative Example 1 includes: a piezoelectric ceramic plate having a diameter of 35.4 mm; a nickel alloy plate having a diameter of 52.0 mm; and a thermoplastic resin film having a thickness of 0.1 mm. The piezoelectric ceramic plate uses an annular edge member having a width of 5.0 mm and a film having a diameter of 60.0 mm.

Comparative Example 2 refers to a frequency characteristic of a piezoelectric speaker which is configured in the same dimension as those of the piezoelectric speaker according to the example of the present invention and does not include an additional mass.

As is clear from the figure, in the piezoelectric speaker according to the example of the present invention, a reproduction capability at a low frequency of 200 Hz or less is enhanced as compared to Comparative Example 1. Further, according to Comparative Example 1, peaks and dips are repeated in a frequency region of 1K Hz or more, thereby greatly disturbing the frequency characteristic, while an extremely flat frequency characteristic is obtained in accordance with the example of the present invention. Furthermore, as compared to Comparative Example 2, it is possible to flatten the frequency characteristic in a frequency region of about 1K Hz or more.

[Effects of the Invention]

According to the invention as described above, it is possible to expand a low-frequency reproduction capability and suppress the turbulence of a frequency characteristic at

high frequencies, thereby obtaining a flat frequency characteristic for allowing satisfactory music reproduction.

4. Brief Description of the Drawings

Figure 1 shows a piezoelectric speaker according to an example of the present invention, where part (a) is a plan view and part (b) is a cross-sectional view taken along line A-A' shown in part (a); and Figure 2 is a graph showing a frequency characteristic of each of piezoelectric speakers according to conventional examples and an example of the present invention.